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J. E. Rogan

# THERMAL SYSTEMS

Space Station Freedom ——— McDonnell Douglas • GE • Honeywell • IBM • Lockheed

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# THERMAL CONTROL SYSTEM

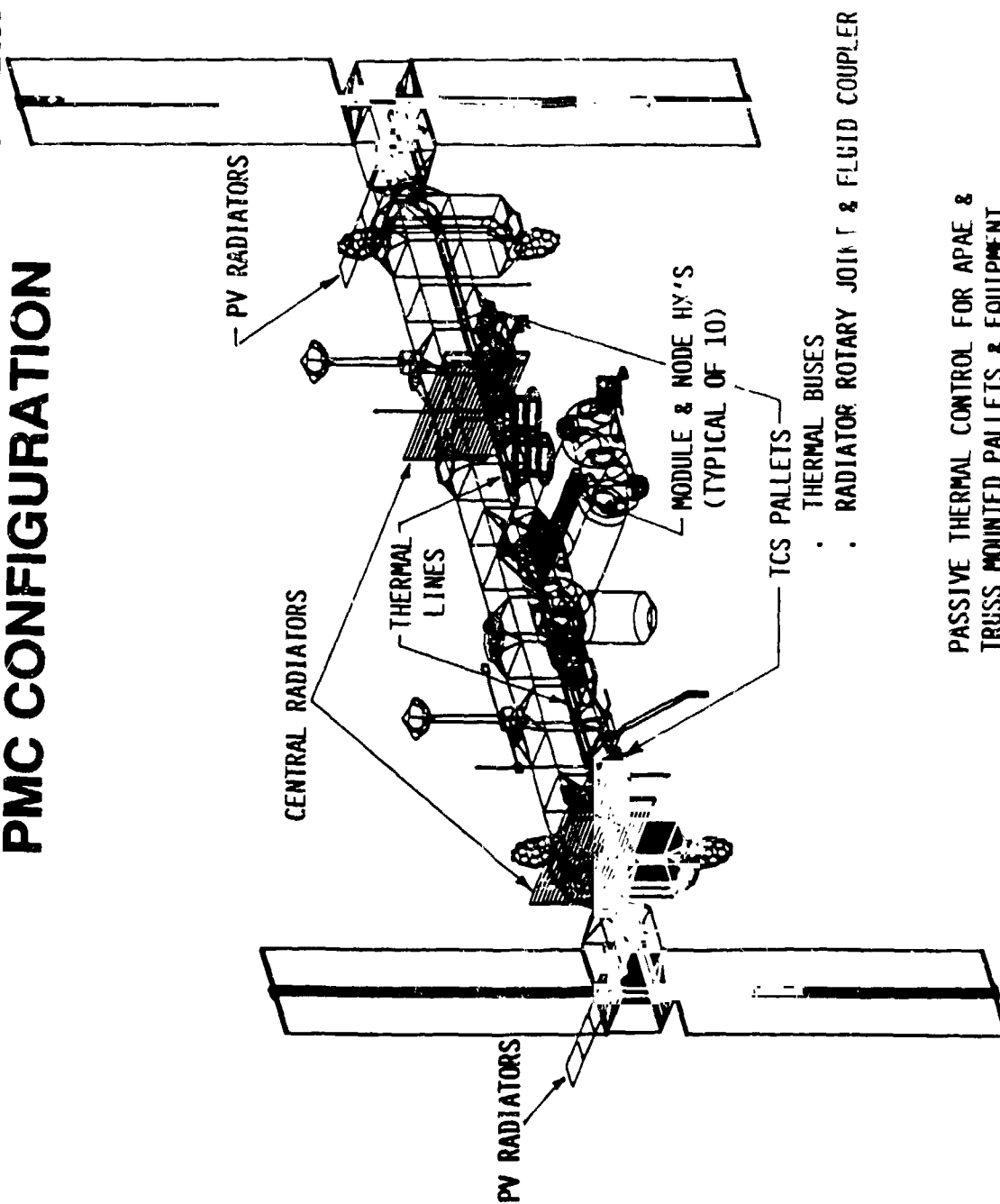
## REBASELINE

BASELINE CONTENT	PMC	AC
<b>External ATCS</b>		
● Central Radiators (2-Phase Ammonia)	Same (erect only as required)	Same
● Central Thermal Bus (2-Phase Ammonia) -Modules and Nodes -Truss Mounted Pallets	Same Passive	Same Passive
<b>Internal ATCS for Pressurized Nodes and Modules (water)</b>		
<b>APAE ATCS for Truss-Mounted Payloads</b>		
<b>PVATCS (1 Phase Fluid and Deployable Radiators)</b>		
	Same	Same
	Passive	Passive
	Same	Same

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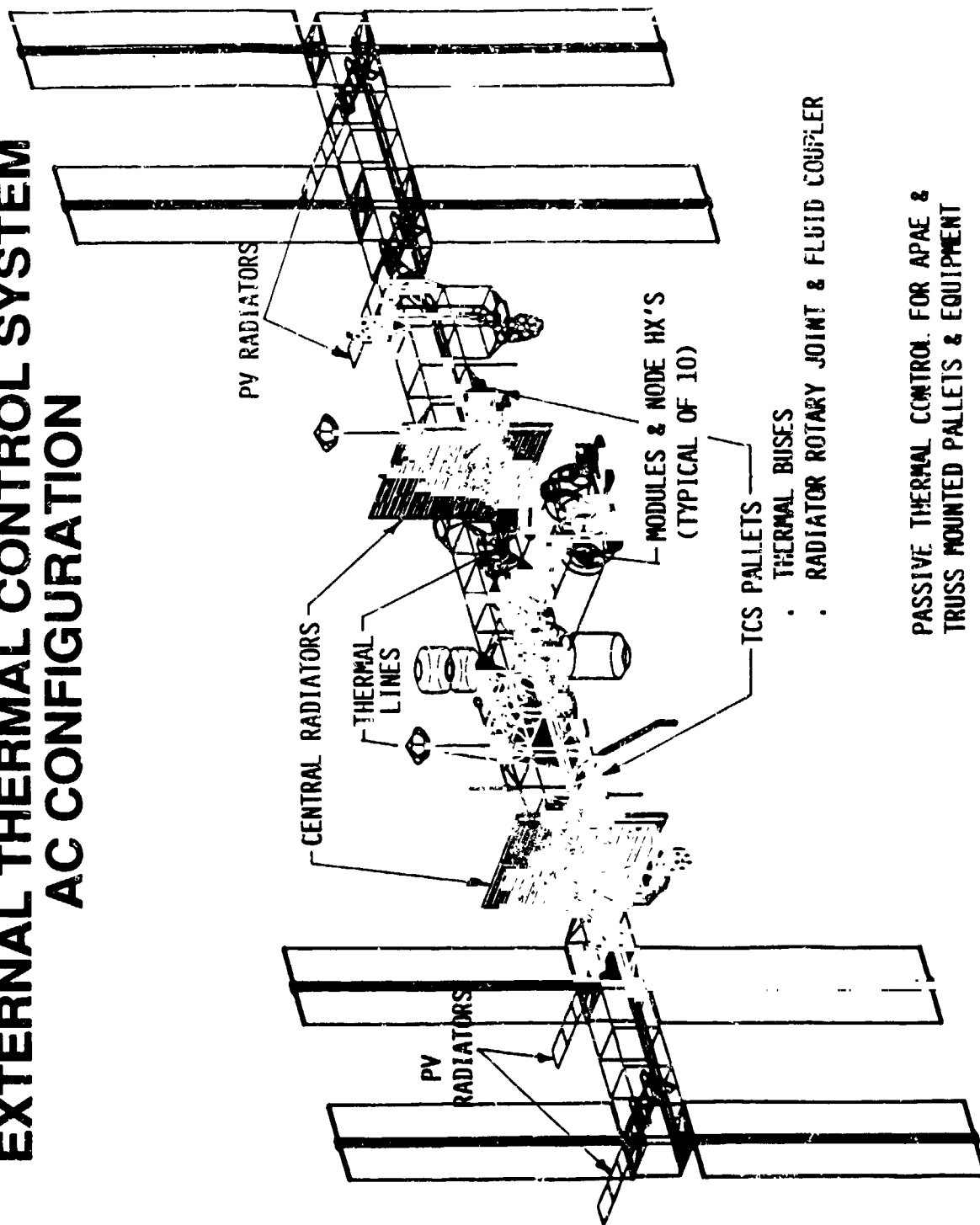
# EXTERNAL THERMAL CONTROL SYSTEM PMC CONFIGURATION



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# EXTERNAL THERMAL CONTROL SYSTEM AC CONFIGURATION



PASSIVE THERMAL CONTROL FOR APAE &  
TRUSS MOUNTED PALLETS & EQUIPMENT

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# EXTERNAL THERMAL CONTROLS SYSTEM REQUIREMENTS

## Functional Requirements

- Waste heat acquisition/transport

## Performance Requirements

- Collect waste heat from each pressurized element or carrier
- Size for 37.5 kW (PMC) and 75 kW (AC) Plus electrical conversion losses, metabolic and environmental heat loads
- Accommodate modular growth, on-orbit assembly
- Provide simple user interface and location flexibility
- Low and moderate temperature loops (35°F and 70°F)
- Quiescent operation (10% of full load)
- Leak detection, isolation, and repair

# EXTERNAL THERMAL CONTROL SYSTEM REQUIREMENTS (CONT.)

<u>Functional Requirements</u>	<u>Performance Requirements</u>
■ Heat rejection	<ul style="list-style-type: none"> <li>● Accommodate modular growth, on-orbit assembly</li> <li>● Limited degradation due to damage or failure</li> <li>● Replaceable radiator</li> </ul>
■ Truss mounted pallets and equipment, APAE and Structures	<ul style="list-style-type: none"> <li>● Passive thermal control</li> </ul>
■ APAE payloads	<ul style="list-style-type: none"> <li>● Provide own independent thermal control</li> </ul>

## IMPLEMENTATION APPROACH

- Truss mounted pallets and equipment, APAEs and structures - passive thermal control
  - Insulation and coatings
    - Multi-layer high performance insulations
      - Utility distribution lines
      - Resource pallets
      - Airlock
      - Mobile Transporter
      - APAE/payload (WP-3)
      - Modules (WP-1)
      - Nodes (WP-1)

## IMPLEMENTATION APPROACH (Continued)

- Selective absorptivity/emissivity optical surface coatings
  - Radiators
  - Truss
  - Resource pallets
  - APAE/payload (WP-3)
  - Modules (WP-1)
  - Node (WP-1)
- Heaters
  - Electrical radiant-type or conductive
    - Utility distribution lines
    - Propulsion Pallet
    - Mobile Transporter
    - APAE/payload (WP-3)



# IMPLEMENTATION APPROACH

(Continued)

- Isolators
  - Low conductivity material
  - Mobile transporter components
  - Airlock
  - Resource Pallets
  - APAE/payload (WP-3)
- Passive Radiators
  - Structural surface area viewing space
  - Resource pallets
  - Mobile Transporter
  - Antennas and cameras
  - APAE/payload (WP-3)

# IMPLEMENTATION APPROACH

(Continued)

## ■ Heat Rejection

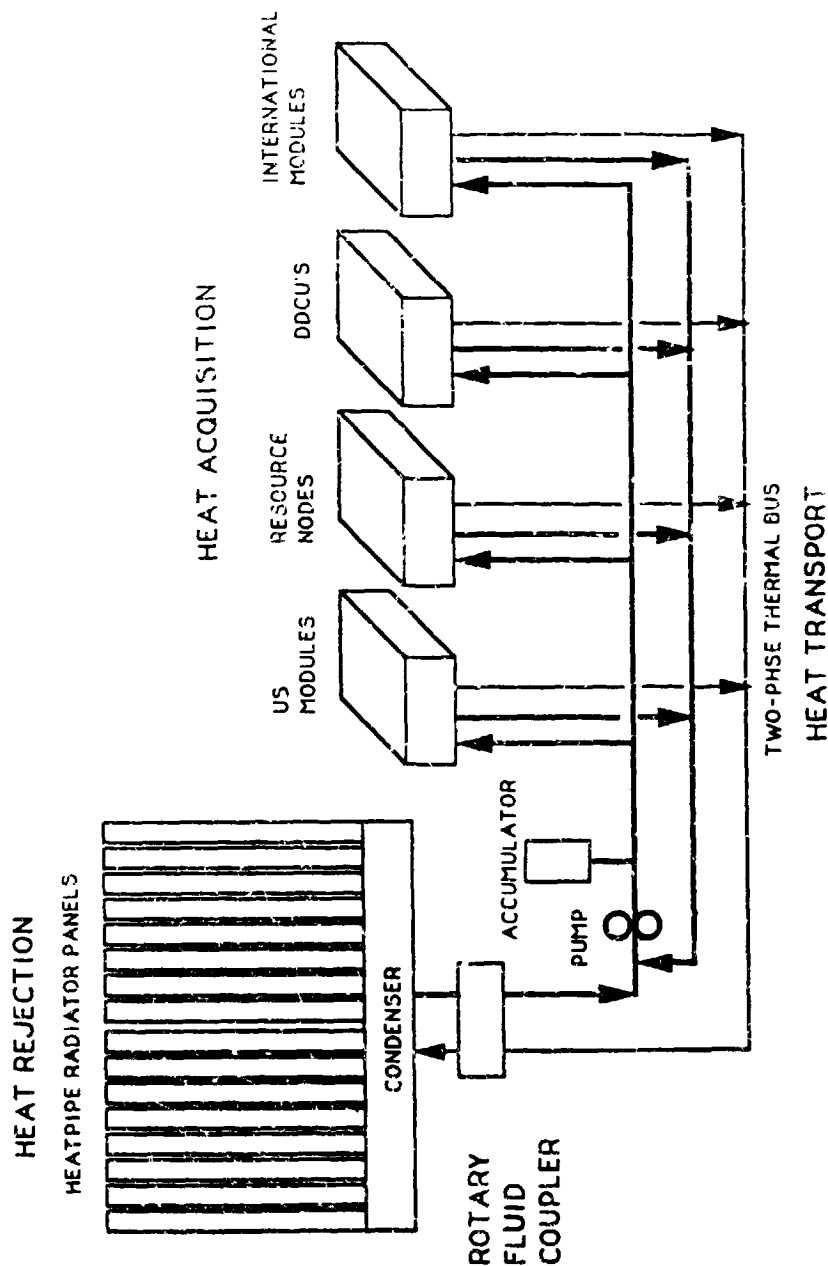
- Individual radiator elements incorporating self-contained, high capacity heat pipes
  - Each element completely independent of all others
  - Facilitates easy handling for on-orbit assembly
  - Allows interfacing radiator with transport circuit through non-invasive technique
  - Allows replacement of elements to maintain indefinite life

# IMPLEMENTATION APPROACH

(Continued)

- Heat acquisition and transport
  - Thermal bus applies heat pipe technology to heat transport
    - Liquid to user interface evaporated. Vapor to radiator interface for condensation
    - All equipment receives the same temperature regardless of location in the circuit
    - Phase change process allows approximately 50 times less fluid to be circulated
- Rotary fluid coupler
  - Allows articulation of radiator to minimize area

# EXTERNAL THERMAL CONTROL SYSTEM

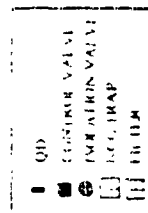


- 35° F AND 70° F TEMPERATURE LOOPS
- BOTH LOOPS REDUNDANT
- BOTH TEMPERATURE LOOPS SERVICE PORT AND STARBOARD SIDES OF SSF

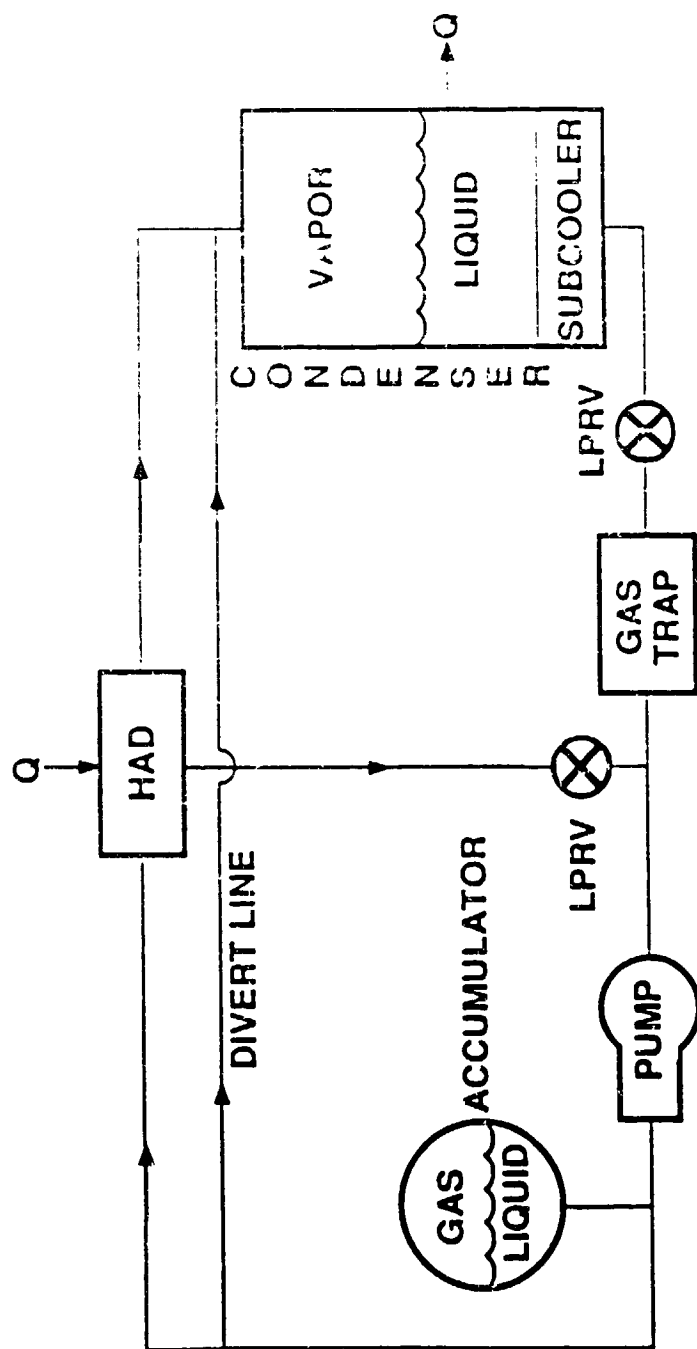
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(FOR CONCEPT EVALUATION ONLY)



# LMSC SYSTEM SCHEMATIC



# DEVELOPMENT ISSUES

## Key Technical Challenges Heat Rejection

- High capacity heat pipe radiator

- On-orbit assembly

## Approach to Challenges

- Two technology options (GAC and LMSC)
- Thermal test bed
- KC-135 tests
- STS-8 concept flight test (OAST)
- STS-29 SHARE\* technology flight test (Advanced Development)
- STS-43 SHARE II\* Development Flight Test (Prime)
- EVA and RMS Options
- WETF evaluations
- RMS ground test facility evaluations
- STS-61 SRAD\* verification flight test (Prime)

\*SHARE - Station Heat Rejection Advanced Radiator Element  
SHARE II - Station Heat Rejection Advanced Radiator Element  
SRAD - Shuttle Radiator Assembly Demonstration

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# DEVELOPMENT ISSUES (Continued)

## Key Technical Challenges Heat Acquisition/Transport

## Approach to Challenges

- |   |   |
|---|---|
| ■ Two phase thermal bus                 | ● Three technology options (Boeing, GAC, LMSC)<br>● Thermal test bed<br>● KC-135 tests<br>● STS-61 TPITS verification flight test (Prime) |
| ■ Rotary fluid coupler                  | ● Three technology options (Boeing, LaRC, LMSC)<br>● Thermal test bed   |
| ■ Leak detection, isolation, and repair | ● Thermal test bed  |



# THERMAL FLIGHT EXPERIMENTS

- SHARE - Station Heat Rejection Advanced Radiator Element
  - One 50 ft advanced development heat pipe radiator panel performance
  - STS-29 (3/89)
- SHARE II - Station Heat Rejection Advanced Radiator Element
  - Two 43 ft station development heat pipe radiator panels performance
  - STS-43 (1/91)
- SRAD - Shuttle Radiator Assembly Demonstration
  - Three heat pipe radiator panels assembled on-orbit by RMS and EVA
  - Thermal performance
  - Accepts heat from simulated or TPITS two-phase thermal bus
  - STS-61 (11/92), manifested with TPITS
- TPITS - Two-Phase Integrated Thermal System
  - 5 kW thermal bus performance
  - Reject heat to Orbiter payload heat exchanger or SRAD-erected radiators
  - STS-61 (11/92), manifested with SRAD